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DETERMINING THE OPTIMAL INVENTORY MANAGEMENT POLICY FOR NAVAL MEDICAL CENTER SAN DIEGO'S PHARMACY

by

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December 2016

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DETERMINING THE OPTIMAL INVENTORY MANAGEMENT POLICY FOR NAVAL MEDICAL CENTER SAN DIEGO'S PHARMACY

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Inventory management in Navy pharmacies uses outdated technologies and strategies and desperately needs updating. The management of inventory should never use a one-size-fits-all approach, and the optimal inventory management system was determined for Naval Medical Center San Diego (NMCSD). This thesis used demand data gathered from NMCSD to investigate the periodic review and continuous review systems with single item ordering and joint quantity ordering to determine which was best for NMCSD. The results of this study are that joint ordering with continuous review is less expensive than single item ordering and periodic review of inventory. It is recommended that NMCSD begin looking into the costs and how to begin implementing a continuous review system.

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LIST OF ACRONYMS AND ABBREVIATIONS

BCF	Basic Core Formula
C	Unit Cost
CHCS	Composite Health Care System
D	Annual Demand
DOD	Department of Defense
DOS	Days of Stock
DUR	Drug Utilization Review
EOQ	Economic Order Quantity
GS	General Schedule
h	Holding cost
IEN	Internal Entry Number
n^*	Ideal number of reorders per year
MTF	Military Treatment Facility
NGO	Non-Governmental Organization
NMCSD	Naval Medical Center San Diego
P&T	Pharmacy and Therapeutics
PAR	Product Activity Report
RLS	Restless Leg Syndrome
ROP	Reorder Point
S^*	Combined Ordering Cost
s	Common Order Cost
SKU	Stock Keeping Unit
SOP	Standard Operating Procedure
TMOP	Tricare Mail Order Pharmacy
VEN(D)	Vital, Essential, Non-Essential

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I. INTRODUCTION

Each year all of the services across the Department of Defense (DOD) spend billions of dollars filling prescriptions, using one of three options: Military Treatment Facility (MTF) pharmacies, Tricare Mail Order Pharmacy (TMOP), or retail pharmacies. For both the government and the Tricare beneficiary, the most expensive option is to fill a prescription using the retail network (Government Accountability Office [GAO], 2008). Through various incentive-based plans, the DOD is trying to shift demand from the retail networks to one of the two preferred methods of filling prescriptions, the MTF pharmacies or TMOP (GAO, 2008). With 9.6 million Tricare beneficiaries in 2012 (Congressional Budget Office [CBO], 2014), many of whom fill at least one prescription every year, this would result in millions of prescriptions to fill throughout the DOD.

With new demand being brought back to MTFs, combined with new technologies, it is necessary and more cost effective for the pharmacies to change how they maintain inventory. New research has made inventory management a science rather than conjecture. Countless different inventory management systems can be customized specifically to meet the customer's individual needs. Using computers, it is easy to gather and analyze data, and even have a computer decide when and how much of an item to order. There are over 80 pharmacies in the Navy system, each managing its own inventory of as many as 2,300 items or stock keeping units (SKU). Managing these items by hand is difficult, time-consuming, and not an efficient use of resources.

This thesis will examine the inventory management of one of the largest pharmacies in Navy Medicine, Naval Medical Center San Diego (NMCSD) Pharmacy. The focus will be on the management of the outpatient division and will not include the demand for inpatient medications. Using data generated from NMCSD, an inventory management system utilizing economic order quantities (EOQ) with joint ordering and random order generation will be evaluated and compared with periodic inventory management.

The NMCSD Pharmacy is responsible for filling an average of 2,500-2,800 prescriptions daily, about 1 million prescriptions each year, with over 2,300 unique stock keeping units (SKU) (research from NMCSD, July 22, 2016). It is surprising that a pharmacy this size still relies heavily on older outdated methods of managing its inventory. Reorders are initiated by visually inspecting each of the 2,300 SKU daily or may result if there is a prescription for a medication and there is none left on the shelf. There is no reliable electronic or other system that the pharmacy's staff can use to determine the actual on hand inventory of any items. If a pharmacist, technician or supply staff would like to know how much of an item is in stock presently, the best and only way to do this is to walk to the shelf and count what is there. This leaves a lot of room for error; there could be misplaced medications or several bottles off the shelf because they are being used, and there is no accountability to compare what is actually present with what should be present. However, NMCSD does use some technology to make their lives easier. When walking the shelves to re-order medications, NMCSD's supply staff use a barcode scanner to enter the quantity on the shelf, and automatically re-order the medication up to the pre-set quantity.

The NMCSD supply workflow is actually very simple. Each day three technicians spend about three hours walking the shelves reordering the medications as needed (Vancheri, 2016). The supply staff has quite a large quantity buffer because their goal day of stock (DOS) is 30 days' worth and place orders five days a week, Monday through Friday, and usually receive their orders the following day (Vancheri, 2016). There are exceptions when the prime vendor is out of stock or there is a manufacturer back order, but this occurs infrequently. When the order cannot be fulfilled by the next business day, the order is then cancelled and must be redone (Vancheri, 2016).

The supply staff has gained significant expertise through on-the-job training and the experience that comes with working a job a many years. If they were to turn over their duties to someone else, it almost certainly would take much longer than nine hours to accomplish; shortages or overstock would almost certainly occur until the new staff got accustomed to the job. While this study looks specifically at NMCSD, not all MTFs have the same resources. At smaller MTFs, there may not be a designated supply staff,

only someone who does it part-time or a military member who will turnover very quickly. A facility like this may use a lot of extra resources to keep their inventory at sufficient levels. The benefits of optimizing inventory management could be transferred to all Navy pharmacies and may even have a larger impact in other pharmacies that do not have the same kind of resources as NMCSD. The largest benefit may be to an overseas pharmacy, where the supply staff turnover is arguably the highest. With a process like inventory management that already has a high learning curve, practicing in an overseas setting has increased demands due to a longer lead-time with much more variability.

The purpose of this thesis is to analyze the demand at NMCSD and use that to determine an optimal inventory management system. The study will compare a continuous inventory management system with a periodic inventory system. The status quo at NMCSD is a hybrid of the periodic and the visual method of inventory management, a continuous review system would allow for a the technician to fill prescriptions rather than order medications, decreasing the patient's wait time or even allowing the technician to go home on time. The hope of the study is to demonstrate the benefits and detriments of each management system to allow NMCSD to make as educated a decision as possible.

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II. BACKGROUND AND LITERATURE REVIEW

A. BACKGROUND

Running a military outpatient pharmacy is very similar to managing a community pharmacy such as Walgreens or CVS. They both have patients in need of medication and customers expect that, in a short amount of time they can go home with medications in hand. The expectation of visiting a pharmacy is that the medication will be in stock and filled in a relatively short period of time. Due to the fact that medications play a significant roll in public health, consumers view a stock outage as an incredibly negative experience; stock outages can result in a loss of customers if it happens frequently. To prevent this, pharmacies must have a high service level on all of their items to prevent such stock outages. However, medications or inventory in pharmacies are the largest asset in pharmacy practice, as much as 75% of a pharmacy's costs can be associated with inventory (Bouldin, Holmes, & Garner, 2011). The cost of inventory is made even more difficult because there is such a growth in the number of drugs on the market as well as the number of people who need these medications (Ali, 2011). The corporate goal of a civilian community pharmacy is to make a profit; a large component of this is to minimize the opportunity cost of inventory by not tying up capital in unnecessary inventory. Military pharmacies are different because troop readiness and the overall health of beneficiaries, active duty, their dependents and retirees, are the goals of a military pharmacy, rather than profit. However, this does not mean that inventory management is not important.

B. LITERATURE REVIEW

This section will introduce different costs associated with pharmacy practice, specifically costs associated with managing inventory. Two different methods of inventory categorization will be explained and later used to decide which medications to focus the study on. Lastly, the different inventory management models that will be used in this study will be introduced.to focus inventory management models

1. Pharmacy Inventory Associated Costs

Acquisition, procurement, carrying, and shortage costs are the four major costs associated with maintaining inventory (Ali, 2011).

a. Acquisition costs

Four factors to determine the acquisition cost of medication inventory and are responsible for the growth in the value of a pharmacy's inventory: price, utilization, mix, and innovation (American Society for Health-System Pharmacists [ASHP], 2008).

(1) Price

Price is the cost of individual medications, and can be driven down with the use of generic medications, if available. This is important because medications, even older medications that have been on the market for a while are getting more expensive. Take the case of the EpiPen®. This is an auto-injectable form of epinephrine that is used to save lives when an anaphylactic allergic reaction occurs. Since 2010, the cost of this vital medication has increased to five times what it was, peaking at just over $600 per pack (Lipton & Abrams, 2016).

(2) Utilization

Utilization or demand is the number of people filling prescriptions or the demand of the medication. Nearly 60% of Americans take routine medications daily and this number has increased significantly since 2000 (Dennis, 2015). This increase in demand can be attributed to the rising number of Americans who take medications to treat conditions such as depression, hypertension, or diabetes (Dennis, 2015). In the last 12 years alone, the number of people taking more than five medications has risen from 8% to 15% (Dennis, 2015). With the demand for medications increasing so dramatically, pharmacies must maintain a higher amount of medications on their shelves, which increases the acquisition costs as well as holding costs.

(3) Mix

Mix is when newer medications are developed that are typically better and more expensive than the medications in which they replace. This type of cost is usually associated with older medications coming off of patents and being replaced with "updated" versions, such as a long acting form or combination product like Caduet®. This medication was released by Pfizer combines the cholesterol-lowering drug Lipitor (atorvastatin) and the hypertension drug Norvasc (amlodipine) (Pfizer, 2016) making it essential for pharmacies to carry three different medications, Lipitor, Norvasc, and Caduet®, each with several dosages, rather than two.

(4) Innovation

Innovation is the cost of medications to treat a condition that was previously untreatable (ASHP, 2008). Perhaps one of the most obvious examples of this was when Viagra® (Sildenafil) was first released to treat erectile dysfunction. Innovative costs are a combination of utilization and mix costs (ASHP, 2008).

All of these costs are tied into the acquisition cost of medications (Ali, 2011), which is essentially the total amount of money that is used on the medications themselves or the cost of the medications themselves. Assuming a proper quantity is ordered, much of the acquisition cost is unavoidable. A pharmacy will order and use what is demanded.

b. Procurement Costs

Procurement costs are the costs involved in purchasing medications such as managing or placing orders and stocking shelves once the medications arrive (Ali, 2011). These costs are mostly personnel costs and are a function of the time and salaries of the individuals who do these tasks. The best way to manage these costs is to remember time is money (Sloan, 2015). Becoming more efficient with ordering is one way to reduce procurement costs. It is also important to remember that spending a lot of time looking for the best price on a medication may actually increase the total price because saving a couple pennies on that medication may cost more in hours of time (Sloan, 2015).

c. Costs

Carrying costs are costs incurred as a result of having the inventory; any loss, theft, or damage, as well as the cost of expiring medications fall into this category (Ali, 2011). The best way to reduce this cost is to minimize wastage and/or shrinkage

d. Shortage Costs

Shortage cost is difficult to put a dollar value on. It can include making rush orders, or the cost of a lost customer, or even the physical health that may be impacted as a result of a stock outage (Ali, 2011). The military system is a little different in that customers are told where they can fill their prescriptions. MTF pharmacy customers are highly incentivized to use MTF pharmacies with 90-day supplies and zero co-pays, but they will still use a network pharmacy at a greater expense to the DOD.

2. ABC Analysis/Pareto Principle

An ABC analysis or the Pareto Principle can determine the best way to allocate resources and help plan inventory (American Society for Health-System Pharmacists, 2008). The Pareto Principle is a very old theory that states 20% of inputs result in 80% of the results (Lavinsky, 2014). In this case, the Pareto Principle implies that 20% of inventory items result in roughly 80% of budget. The ABC Analysis takes this principle and applies it slightly differently. While the Pareto Analysis divides items into two categories, 20% and 80%, the ABC analysis divides it into three: A, B, and C items (World Health Organization [WHO], 2012). There are some variations in how the categories are divided and often there is a natural or obvious divide. Typically the A items represent about 10–15% of the items or 70–80% of the total cost, B items approximately represent the next 20–25% of the inventory or 15–20% of the budget, and the remaining 60–70% of the items account for only 5–10% of the budget (Devani, Gupta, & Nigah, 2010). The ABC analysis can have a significant impact on identifying areas for improvement. Any cost reduction of the “A” items will have the most meaningful and immediate impact on inventory costs, while the “C” items will have a minimal and relatively insignificant impact on cost savings. For the purpose of this study, the ABC Analysis will be used to help decide which items to focus on to decide order

quantities and re-order points. By ordering smaller quantities more frequently, holding costs can be reduced, however this may lead to an increase in procurement costs from more frequent ordering and receiving. It may also be possible to reduce safety stock with more frequent orders. Not included in the scope of this study, important savings opportunities can be observed by focusing on finding lower cost sources of medications of "A" items as well as monitoring their expiration dates more closely to ensure proper stock rotation (WHO, 2012).

3. Vital, Essential, Non-Essential Categorization

Another way to differentiate medications is to use the VEN system, sometimes called the VED system or simply the VN system. With this system the "V" is for vital medicines, the "E" is for essential medicines and the "N" is for non-essential medicines (or "D" for desirable). For the purpose of this paper, the VEN nomenclature will be used. The classification for each of these medications is highly subjective, but typically the vital medications are those where the cost of a stock out is typically very high. These are medications that can save someone's life, have severe withdrawal side effects or are important to maintain the standard level of care (WHO, 2012). These are the drugs that must be available at all times. The Medications in the "E" category are still vital to have, but are not as critical. They may be rarely used or have substitutes or alternatives that do not degrade patient outcomes. All others are in the "N" category. These are the medications that are nice to have, but can be survived without (WHO, 2012) (Devani et al., 2010). Table 1 is one way to determine how to differentiate between the different categories. Controlled substances usually receive a lot more scrutiny and are the only classification of medications for which there is an accurate inventory readily available electronically and manually. Considering the regulations required for controlled substances, denoted as schedule II-V, these medications might be considered as vital or essential, simply due to the amount of scrutiny and documentation required for maintaining even a small amount of inventory.

Table 1. Sample VEN Guidelines. Source: WHO (2012).

Characteristic of Medicine or Target Condition	Vital	Essential	Non-essential/Desirable
Occurrence of target Condition			
Persons affected (Percent of Population)	>5	1-5	<1
Persons Treated (number per day at average health center)	>5	1-5	<1
Severity of Target Condition			
Life-Threatening	Yes	Occasionally	Rarely
Disabling	Yes	Occasionally	Rarely
Therapeutic effect of medicine			
Prevents serious Disease	Yes	No	No
Cures serious disease	Yes	Yes	No
Treats minor, self limited symptoms/conditions	No	Possibly	Yes
Has proven efficacy	Always	Usually	Possibly
Has un-proven efficacy	Never	Rarely	Possibly

Using the ABC Analysis or the VEN Analyses may not be the right way to differentiate medications for every pharmacy. The ABC analysis really is suited for pharmacies that are trying to reduce inventory costs. The VEN analysis lends itself better to an NGO or country that has significant constraints on their medication budget. It is a very good tool for those hospitals that have a restrictive formulary. There is also the option to combine these to analyses into the ABC-VEN matrix analysis (Devani et al., 2010). This is performed by assigning each medication an "A," "B," or "C" from the ABC analysis and a "V," "E," or "N" resulting in nine categories: "AV," "AE," "AN" and so on. These categories are then divided into Category I, II, and III as shown in Table 2 (Devani et al., 2010).

Table 2. ABC-VEN Categorization.
Adapted from Devani et al. (2010).

Category	ABC-VEN Classification
I	AV, AE, AN, BV, CV
II	BE, BN, CE
III	CN

This classification opens up the most important category of medications, making it important to track and stock some of the B and C items. This is important because with this model, the acquisition costs are not the sole basis for dividing the medications. The VEN method takes into account the intangible shortage cost to the patient or society if they cannot get the medication immediately.

4. Methods to Manage Inventory

Much of what has been stated previously has been industry standards and recommendations. But one of the biggest differences between managing a civilian pharmacy compared to a military pharmacy is money and profit. The Navy spends $500M in acquisition costs of medications worldwide (Boyle, 2013); much of that budget is spent in only a couple of the Navy's largest facilities. Pharmacies have three basic approaches of managing inventory: visually, sometimes referred to as "looking it over," periodically, or physical inventory, and continuously, (Ali, 2011) *(Elements*, 2013).

a. Visual Review Method

The visual method is as it sounds; the supply personnel will visually inspect each item and once it falls below a certain level, it will get reordered (Bouldin et al., 2011). In this system, the pharmacist will often have a "want book," which is a notebook where the pharmacy staff keeps track of medications that need ordering throughout the day, and is very common in smaller pharmacies (Bouldin et al., 2011). Typically as the pharmacy fills prescriptions the staff will make note of a low medication or puts the item's barcode in the notebook. At the end of the day an order is generated using the notes (Bouldin et al., 2011). Some of the benefits of this system include low cost of implementation, convenience, and informality (Bouldin et al., 2011). This is an ideal system for a small pharmacy without much inventory; however there is a huge risk of stock outs due to oversight or missing an order.

b. Periodic Review Method

The periodic method is very similar, except that the supply staff inspects the inventory at preset time periods such as weekly or monthly. It is even possible to have multiple periods, fast moving items might be re-ordered daily while slower moving items only weekly or monthly. Like the visual system, the periodic system, orders when the stock falls below the reorder point (*ROP*). This method is a little more formal than the visual, which allows for some data to be generated. With this data, the manager can do minimal analysis. The benefits are that it is also inexpensive to implement and the limited data generation (Bouldin et al., 2011). The disadvantages are the time investment needed as well as the risk of stock outs and greater safety stock.

c. Continuous Review Method

The last and most efficient method is continuous inventory, known in the pharmacy literature as a perpetual inventory system. A majority of civilian pharmacies use a computer based continuous inventory system (Ingersol, 2015) but a continuous review can be done on a small number of items by hand (Bouldin et al., 2011). With continuous inventory systems, inventory is tracked at the level of sale (dispensing) and a real time inventory can be known. The system can place an order once the inventory gets below the *ROP*. In addition to re-ordering and keeping track of the inventory, a continuous system can give detailed analyses with all of the data it collects, such as average inventory, variations in demand or any kind of seasonality (Bouldin et al. 2011).

This is the best inventory management system of all the choices. It can save money by reducing inventory, provide a total value of the inventory in stock, and reduce the risk of stock outs compared to the other systems. An added benefit is the continuous system should reduce the work spent walking the shelves and entering reorder information (Willard, 2012), allowing for those resources to be used in other places. The biggest disadvantage of the continuous system is the cost.

For many pharmacies, the system that is best for the pharmacy largely depends on the pharmacy itself, specifically its budget. The periodic/visual methods are the least expensive, at least in the start up phase and for smaller pharmacies, but they may be at an

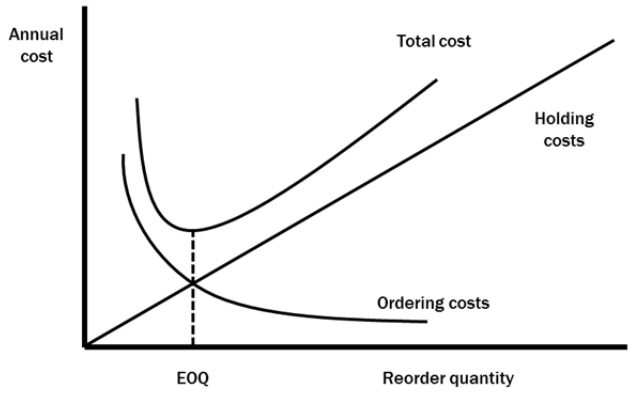
increased risk for error. The risk of stock-out increases if the supply staff inadvertently misses an item that is below the *ROP*. This may put the patient in danger, and is also bad for business. There are strategies for minimizing the safety impact to patients; such as partially filling a prescription to ensure they have enough medication until the pharmacy is resupplied. If this happens often, the patient is likely to look for another pharmacy. There are several benefits of utilizing a continuous inventory system beyond the obvious of saving personnel costs. It can help the pharmacy identify lost items due to shrinkage, help with reporting (financial statements as well as an easy way to view demands and utilization), help track turnover rates, and even help with forecasting (Ingersol, 2015).

5. How Much to Order?

a. Economic Order Quantity (EOQ)

The economic order quantity is a mathematical solution to minimize costs associated with ordering and holding inventory. AT larger and larger order quantities of an item, carrying costs will increase due to the increased inventory (Bouldin et al., 2011). Conversely, as the order quantity increases the procurement cost will decrease due to decreased orders; the EOQ takes these two costs and determines the quantity to order at which the total cost of managing inventory is the lowest (Bouldin et al., 2011). Figure 1 shows this relationship graphically.

Figure 1. Economic Order Quantity. Source Seftil (2016).



The holding cost is an approximation of a variety of factors; for a pharmacy, the average annual holding cost is 20–30% of the value of the inventory (National Community Pharmacists Association, 2008). This means that a pharmacy that has an average inventory value of $1 million will pay about $200-300 thousand to maintain that inventory. Calculating the EOQ for each item and then maintaining and updating the levels as demands shift can be a very tedious process. Fortunately technology can take care of this task, freeing up the pharmacy staff to take care of patients and other tasks (Bouldin et al., 2011). The limitations of the EOQ method include assumptions of continuous use and prices without fluctuations (Bouldin et al., 2011).

b. Joint Ordering Strategy

The purpose of joint ordering is to take a group of coordinated items and order them in as one whole unit (Aksoy & Erenguc, 1988). This system of inventory management has many different versions, but one thing they all have in common is that they take items with a large set-up cost or a high fixed cost per order and combine orders resulting in significant savings (Pantumsinchai, 1992). The execution of joint ordering will largely be dependent on the policies of the individual site that the organization uses to manage inventory; when the site determines the order all of the items in the group (Pantumsinchai, 1992). The reorder point is dependent on the amount of risk the pharmacy is willing to take, as well as the holding and shortage costs of the items. A couple examples of ordering triggers are: once one item is below its *ROP*, or the re-order

can trigger once several items are below the *ROP*. With this system, the item(s) that trigger the replenishment are ordered normally, but for the remaining items the benefit comes with procuring medications at a reduced set-up cost (Pantumsinchai, 1992). This system works best when using the (S, s) method of inventory management, where the quantity ordered is variable based on the difference between the maximum inventory level (S) and the inventory level when the order is placed (Pantumsinchai, 1992). This type of inventory management system is difficult to manage without the use of computer-assisted inventory, but can also be used with a modified EOQ type method (Aksoy & Erenguc, 1988). With the modified EOQ system, rather than optimizing each individual item, a group is optimized so that the order quantities correspond with the average demand so that each item should need to be ordered at approximately the same interval (Aksoy & Erenguc, 1988).

6. When to Re-order

Determining when to reorder an item largely depends on the amount of safety stock needed or amount of risk of stock out management would like to assume. The demand during lead-time is also important in determining when to reorder (Krajewski & Ritzman, 1996, p. 554–555). Service level is the probability that an item will not run out of stock in an order cycle (Krajewski & Ritzman, 1996, p. 554–555) and it is used to manage the risk of stock outs. Service levels are usually given in percentages and the higher the percentage the lower the risk of stock outs. Having a higher service level comes at a cost; more inventory is required, which means paying more holding cost. Different managers might determine with different service levels, but they all must consider the objective costs of having no inventory and maintaining extra inventory as well as the subjective non-monetary costs into account. Determining the appropriate service level is a balancing act, management must decide if based on what they think is best for their organization.

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III. METHODS

This chapter will focus on how this study was completed. It will discuss the source of the data being analyzed, and how the ABC analysis was completed, and how the VEN categorization was applied to the data.

A. DATA SOURCE

1. Demand Data

This study focuses on one pharmacy, NMCSD Pharmacy, and the data comes directly from their pharmacy. Currently, there is no good way to extract the demand of medications in enough detail from their computer pharmacy system, Composite Health Care System (CHCS). One of the benefits of CHCS is its ability to store and report data, however it is an old, non-Windows based system that requires a lot of specialized knowledge to operate to its full potential. CHCS does have an inventory management feature as well as an inventory-reporting tool (Science Applications International Corporations (SAIC), 1996). Another option to get demand data is to use the Drug Utilization Review reports, which divides the data into individual prescriptions per day. The last option of the pre-set reports is the product activity report (PAR). This report is very useful in gathering data for one or two medications for a small amount of time, but must be run for each day to get daily demand and for each medication individually. That is 365 reports needed per medication. Ultimately the data for this project came from an ad hoc report that made the PAR report include the totals for the specified time (one day) and all of the medications dispensed for that day (Science Applications International Corporations (SAIC), 1996). The difficulty with ad hoc reports is they require special training to build (Science Applications International Corporations (SAIC), 1996) and not all sites may have someone with that training.

The specialized PAR report included a total number of units dispensed during the specified time period as well as the unit cost of the medication. The medications were identified by internal entry number (IEN), a unique number that identifies each unique item within the system. Each of these 365 reports contained a number of items as small as

200 up to 700 different items used for that day which were individually imported into Microsoft Excel. The relevant data was filtered and combined into one large table using the excel ad-in "ablebits." Ablebits is a tool that will merge 2 tables adding the extra columns with the new data and extra rows for the data that had not been used yet. The resulting table included every medication used for the year, approximately 2,300 medications, and the demand separated into each day.

2. Procedural Data

The procedural data used in this study was obtained during a site visit to NMCSD pharmacy, electronic correspondence with the supply staff, and the author's personal knowledge of the site gained from working there as a pharmacist for several years. The information gathered directly from NMCSD's supply staff included, but is not limited to:

- Number of orders placed per year
- Number of items per order
- Time spent on the order from start to finish
- How the order was generated

B. CATEGORIZATION OF MEDICATIONS

1. ABC Categorization

Setting up an ABC analysis is easy using a spreadsheet program. It requires ranking the different products by each individual percentage of the total value of the inventory and graph the cumulative percentage on the Y-axis and the total number of products on the X-axis. To find the percentage of use, multiply the demand (units purchased) over a given period of time by the unit cost, and then divide the cost per period of time by the total amount spent and graph (WHO, 2012). An example of the table and graph can be seen in Table 3.

Table 3. ABC Analysis from NMCSD. Adapted from WHO (2012).

Drug Name	Unit Cost	Total Demand (Units)	Total Cost	% total	Cumulative % Total	Category
TRUVADA 200MG/300MG ORAL TAB	$50.92	87,498	$4,455,203.72	4.25%	4%	A
FLUTICASONE (FLONASE) 50MCG NAS INH 16GM	$64.94	47,400	$3,078,156.00	2.94%	7%	A
LANTUS SOLOSTAR 300U/3ML PREFILLED PEN	$51.99	55,368	$2,878,656.14	2.75%	10%	A
ABOBOTULINUMTOXINA(DYSPORT)300UNITS INJ	$147,336.77	16	$2,357,388.32	2.25%	12%	A
RIZATRIPTAN (MAXALT) 10MG ORAL TABLET	$480.21	4,659	$2,237,298.39	2.13%	14%	A
NORELGESTROMIN/ETHIN.ESTRADIOL PATCH--TD	$15.85	5,025	$79,629.50	0.08%	80%	B
APIXABAN(ELIQUIS)2.5MG ORAL TAB	$1.77	44,884	$79,499.54	0.08%	80%	B
ALBUTEROL SULFA(PROAIR HFA)90MCG INH HFA	$6.84	11,588	$79,261.92	0.08%	80%	B
AUGMENTIN XR AMOX/POT 1000-62.5MG TAB--P	$2.99	26,358	$78,751.11	0.08%	80%	B
ERLOTINIB HCL(TARCEVA) 150MG ORAL TAB	$118.68	660	$78,331.44	0.07%	80%	B
ARIPIPRAZOLE (ABILIFY) 30MG TAB	$19.39	854	$16,563.05	0.02%	95.00%	C
AMINOCAPROIC ACID (AMICAR) 500MG TAB	$6.02	2,748	$16,546.17	0.02%	95.02%	C
DEFERASIROX (EXJADE) 125MG ORAL TAB	$14.50	1,140	$16,526.33	0.02%	95.03%	C
EPOETIN ALFA (PROCRIT) 20,000 U/ML INJ	$294.97	56	$16,518.13	0.02%	95.05%	C
PALIPERIDONE (INVEGA) 6MG ER TAB	$13.30	1,238	$16,469.53	0.02%	95.07%	C

2. Vital, Essential, Non-Essential

Classifying each medication as vital, essential, or non-essential is completely independent of the ABC analysis and must be done separately. Each pharmacy would divide their formulary based on their own needs and criteria. For this study each medication was divided based on four major criteria seen in Table 4.

Table 4. NMCSD Criteria for VEN Classification.
Adapted from WHO (2012).

Characteristic of Medication or Target Condition	Vital	Essential	Non-Essential
Demand			
Days used at NMCSD	>260 days	100<days<260	<100 days
Miscelaneous			
Prevents serious Disease	Yes	No	No
Controlled Substance	CII	CIII-IV	CV
Importance of Missed doses	Can't miss	OK	PRN

The number of days used at NMCSD and the controlled substance classification criteria are very objective and require no interpretation. The other two, the prevention of serious disease and the importance of missed doses, require knowledge of the medications that they are classifying or the conditions the medications are treating.

Dividing each medication into vital, essential, and non-essential medications would be a decision for the Pharmacy and Therapeutics Committee (P&T) (WHO, 2012) and not only a single pharmacist or doctor. However, for this study the author used his professional judgment and experience to determine if the medications prevented serious disease or if a missed dose would have serious consequences.

C. NECESSARY EQUATIONS

1. Economic Order Quantity

With the EOQ inventory management method, the order cost (S) is the fixed cost of placing an order for just one item at a time and for this study the same S is used for all medications ordered. The equation used to determine EOQ follows.

$$EOQ = \sqrt{\frac{2DS}{hC}}$$

Where:

D = item annual demand
S = order Cost
C = item Cost
h = holding Cost, as a percentage of the cost

2. Joint Ordering Strategy

With the joint order strategy, the goal is to find the optimal number of orders per year (n^*) and work backwards to determine the optimal joint order quantity (Q_i). One big difference between the joint ordering strategy compared to the EOQ method is the break-up of the costs into the common order cost (S) and the item specific costs (s). The combined order cost (S^*) is S plus the item specific cost of every item in the group. For example in a pharmacy walking the shelves to generate an order is a common ordering cost and putting the medications away after the order has been received is a item specific cost. Using n^* the optimal joint order quantity for each individual item can be determined using the equations provided (Chopra & Meindl, 2013). The Q_i is simply the annual demand for an item divided by the calculated n^* (Chopra & Meindl, 2013).

$$S^* = S + s_1 + s_2 + ... + s_n$$

$$n^* = \sqrt{\frac{D_1 * h * C_1 + D_2 * h * C_2 + ... + D_n * h * C_n}{2S^*}}$$

$$Q_i = \frac{D_i}{n^*}$$

Where:

Q_i = joint order quantity for Item i
S^* = total order cost
S = common order cost
s = item specific order cost
D_i = annual demand for Item i
n^* = optimal number of orders per year

3. Reorder Point

Two components make up the *ROP*, the demand during lead-time and the amount of safety stock needed. Many formulas can be used to determine this, taking into account the variability in demand as well as variability in lead-time. Fortunately at NMCSD the lead-time is relatively constant with almost no variability, therefore this model assumes no variability in lead-time. The formula used to determine *ROP* is

$$ROP = d * LT + (Z * \sqrt{LT} * \sigma)$$

Where:

ROP = re-order point
d = daily demand
LT = lead time in days
Z = number of standard deviations from mean (Z score)
σ = standard deviation of daily demand

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IV. ANALYSIS

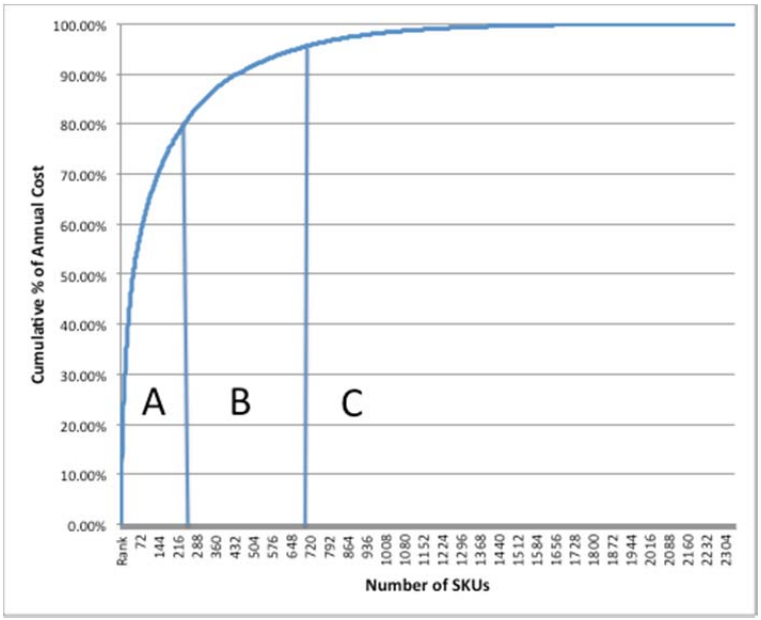
A. ABC ANALYSIS

The ABC analysis was performed to differentiate the 2,300 SKUs that the pharmacy carries. For the purpose of this paper, the A items are the most important either as a result of the demand or because they are expensive in relation to the other items. The B and C items account for a much smaller percentage of the overall pharmacy inventory budget. In this study, the A items represent 80 percent of the total budget, the B items are only 15 percent and the C items include the last 5 percent of the budget. However, there are only 241 items in the A category, 426 in the B, and 1677 in C as shown in Table 5 or graphically in Figure 2. The percentages of cost assigned to each group were assigned arbitrarily based on being a number that is a factor of five and the number of items that would correspond with the assignment.

Table 5. NMCSD ABC Analysis Breakdown.

Category	Percent of Cost	Number of SKUs	Percent of SKUs
A	80	241	10
B	15	426	18
C	5	1677	72

Figure 2. NMCSD ABC Analysis (July 2015–July 2016).



B. VEN CATEGORIZATION

A unique aspect of health care inventory and especially medications is that cost and demand are not always the best indicators of what is most important to manage inventory. Sometimes the subjective stock out cost of a medication is significantly high and that item must be managed as closely as an A item, even if it is a C item. As mentioned earlier, a committee would do this assignment into Vital, Essential, and Non-Essential items locally or as an organization. The results of this analysis can be seen in Table 6.

Table 6. NMCSD VEN Analysis Breakdown.

Category	Number of Medications
V	336
E	476
N	1531

C. ABC-VEN CATEGORIZATION

The ABC analysis is not enough to use when evaluating the inventory of a pharmacy and should be used in conjunction with a tool that takes non-monetary factors into consideration. The VEN analysis tool fills this gap. The results of combining the ABC analysis and the VEN analysis can be seen in Table 7. Category I medications replace A as the most significant category to watch. Category I medications will be used to conduct the rest of the analysis of this study. It is assumed that all benefits achieved from modifying the Category I medications will apply to Category II and III because the are used infrequently or represent such a small fraction of the overall acquisition costs. An added benefit of this method of categorization is it breaks the Category I medications into five joint ordering groups: AV, AE, AN, BV, and CV.

Table 7. Results of Combining ABC and VEN Analysis.

	AV	AE	AN	BV	BE	BN	CV	CE	CN	Total
Category I	102	82	57	96			138			475
Category II					156	174		238		568
Category III									1300	1300
Total	102	82	57	96	156	174	138	238	1300	2343
	241			426			1676			

D. DEMAND ANALYSIS

Both models evaluated require a few key pieces of information: the demand, holding cost, unit cost and ordering cost. Much of that information is given in the data and the holding cost of inventory in a pharmacy is 20% (National Community Pharmacists Association, 2008). One thing that must be determined is the ordering cost.

1. How Much to Order

a. Ordering Costs

The information about the time spent on each activity involved in ordering was determined from email correspondence with the supply officers at NMCSD. Also missing

in this analysis was the fixed shipping and handling fee that would be a fixed cost charged per order. This cost was not known by anyone interviewed.

(1) Supply Staff

The NMCSD is currently made up of three different classifications of employees, General Schedule (GS) pharmacists and technicians and military technicians or Corpsmen. The pay of these individuals is based on their rank or GS grade and step and is variable based on the people who fill these positions. The assumptions made to calculate the ordering costs is that the GS Pharmacist is a grade of 13 step five, the GS technicians have a grade of nine step five, and the corpsman is an E3 with over three years. Locality pay was also included in the calculation of the costs of these workers. Their salary breakdown can be seen in Table 8.

Table 8. NMCSD Supply Staff Salary Breakdown, Adapted from San Diego Locality Area-General Schedule Localities (2016), Military Pay Chart for 2016 (2016), Defense Travel Management Office (2016).

Job Type	salary/year	Daily wage	Hourly Wage
GS Pharmacist*	$104,392.00	$417.57	$52.20
GS technician**	$60,533.00	$242.13	$30.27
Military Tech***	$51,768.00	$207.07	$25.88

*Assuming GS13 Step 5, **Assuming GS9 Step 5, ***Assuming E3 >3 years with dependents.

(2) Ordering Tasks

The personnel costs associated with the ordering cost can be broken into three categories which Table 9 summarizes

- **In-processing of the order**—This includes verifying the invoice with the medications that were included in the order and putting the medications away. Each order takes two technicians four hours to complete (Vancheri, 2016).
- **Walking the shelves/Order building**—This task the technicians walk the shelf visually inspecting each item to determine if it needs reordering. If a medication needs to be reordered the technician scans the barcode adding the item to the order and counts the medication to determine how much to

order. This task is done daily and usually takes three technicians three hours to complete (Vancheri, 2016).

- **Managing the Order—**This task is probably the hardest to quantify and counts as the catch all in the ordering process. This includes monitoring the orders insuring that all items needed are actually ordered. If there is a shortage of an item the pharmacy supply staff search the different generics looking for an equivalent. They monitor drug shortages ensuring that once a medication is available again, it is reordered promptly. This task is done daily and it was estimated that it takes two technicians five hours and one pharmacist two hours daily (Vancheri, 2016).

Table 9. Order Cost Breakdown Adapted from (Vancheri, 2016).

Task	Number of Techs	Number of Pharmacists	Tech hours required/order	Pharmacist Hours	Cost/order
In-processing of Order	2	0	4	0	$242.13
Walking shelves/Building Order	3	0	3	0	$272.40
Managing Order	2	1	5	2	$407.06
Total:					$921.59

(3) Determining Common Order Costs (S) and Total Order Cost (S^*)

The first task of determining the order cost was deciding what is a common order cost and what is item specific. To guide this analysis, a common cost was any cost that would need to be paid if only one item was ordered. The first common cost is "walking the shelves/building the order." This is a common cost because the supply staff could potentially walk the shelves to build the order and only need one item. This is a very hypothetical situation to help build the model. Managing the order is a common cost because this cost is fixed.

For the *EOQ* model, S is the cost of managing the order plus building the order. To make the scenario a little more realistic, the cost of managing the order for the EOQ method is divided by six. Twelve man-hours for a one-item order is not very realistic, however two man-hours managing an order is a reasonable amount of time. The In-processing of the item for a one-item order is negligible because it would take almost no time to complete. The resulting S is $340.24 per order.

The S^* in the joint ordering strategy is a little more complex. No manipulation of the order building or order management cost is necessary The common cost (S) is the same for all five joint order groups and is \$679.46 when using the periodic system. If a continuous review system were to be used, this would eliminate the order building cost reducing S to \$407.06. The item specific cost for each category prorated cost of in-processing the order. An average order for NMCSD contains approximately 177 different SKUs (Vancheri, 2016). To get the per item in-processing cost the \$242.13 in-processing cost was divided by 177 to equal \$1.37 per item. For each group, the total number of items in the grouping is multiplied by \$1.37 for the total item specific cost for that grouping. For the AV items in the item specific cost is \$1.37*102 items and equals \$139.53. When added to the \$679.46 common cost the S^* is \$818.99. The ordering costs for all groups using the periodic system and continuous system are summarized in Tables 10 and 11 respectively.

Table 10. Summary of Order Costs at NMCSD, Periodic Review. Adapted from Chopra & Meindl, (2013).

Ordering Cost	EOQ	AV	AE	AN	BV	CV
Common (S)	\$340.24	\$679.46	\$679.46	\$679.46	\$679.46	\$679.46
s_{av}		\$139.53				
s_{AE}			\$112.17			
s_{AN}				\$77.97		
s_{BV}					\$131.33	
s_{CV}						\$190.15
Total	\$340.24	\$818.99	\$791.63	\$757.43	\$810.78	\$869.60

Table 11. Summary of Order Costs at NMCSD, Continuous Review. Adapted from Chopra & Meindl, (2013).

Ordering Cost	EOQ	AV	AE	AN	BV	CV
Common (S)	$203.53	$407.06	$407.06	$407.06	$407.06	$407.06
s_{av}		$139.53				
s_{AE}			$112.17			
s_{AN}				$77.97		
s_{BV}					$131.33	
s_{CV}						$190.15
Total (S*)	$203.53	$546.59	$519.23	$485.03	$538.38	$597.21

b. Inventory Models

As discussed in the methods chapter, determining the *EOQ* or Q_i of an item is a simple math problem when you know the holding cost, unit cost, demand and order cost. The Q_i is made a little more difficult because the common order cost and item specific order cost must be known. The standard holding cost for a pharmacy is approximately 20–30% (National Community Pharmacists Association, 2008) and for the purpose of this model 20% was used for all models. The order costs can be determined by referencing Tables 10 and 11. One important assumption to remember is that in the *EOQ* model, all items are ordered independently and the order cost is based on a one-item order.

To determine which system is best, the overall order cost should be compared across all of the models. In this study *EOQ* and Q_i each with periodic and continuous review have been compared and their total annual costs are shown in Table 12. For the initial analysis, only the order cost and the holding cost of the average inventory will be compared. The holding cost associated with safety stock will not be included because this is cost is not relevant when deciding if periodic or continuous review is best. Important to note that in most cases the quantities derived using the *EOQ* or the Q_i method will not be available for purchase in those quantities. Rounding up or down to the nearest multiple of the nearest bottle size will not impact the cost much. For example, if the *EOQ* is 637,

order 700 tablets if the medication comes in bottles of 100 or 690 if the medication comes in bottles of 30.

Table 12. NMCSD Pharmacy Annual Cost Analysis of Category I Medications. Adapted from Chopra & Meindl, (2013), Bouldin et al., (2011).

	AV		AE		AN	
	EOQ	Joint	EOQ	Joint	EOQ	Joint
Periodic Review						
Holding Cost	$343,950.11	$61,749.90	$219,960.32	$41,431.94	$154,276.32	$34,337.66
Ordering Cost	$343,950.11	$61,749.90	$219,960.32	$41,431.94	$154,276.32	$34,337.66
Total Cost	$687,900.22	$123,499.81	$439,920.63	$82,863.89	$308,552.63	$68,675.33
Continuous Review						
Holding Cost	$266,020.15	$50,446.18	$170,123.15	$33,554.80	$119,321.40	$27,477.96
Ordering Cost	$266,020.15	$50,446.18	$219,960.32	$33,554.80	$119,321.40	$27,477.96
Total	$532,040.30	$100,892.37	$390,083.46	$67,109.60	$238,642.80	$54,955.92
	BV		CV		Total Annual Cost	
	EOQ	Joint	EOQ	Joint	EOQ	Joint
Periodic Review						
Holding Cost	$109,462.93	$17,705.21	$359,327.35	$3,464.21		
Ordering Cost	$109,462.93	$17,705.21	$359,327.35	$19,259.74		
Total Cost	$218,925.87	$35,410.42	$718,654.70	$22,723.95	$2,373,954.06	$333,173.40
Continuous Review						
Holding Cost	$84,661.54	$14,427.62	$277,913.32	$2,725.77		
Ordering Cost	$84,661.54	$14,427.62	$277,913.32	$16,810.01		
Total	$169,323.08	$28,855.24	$555,826.63	$19,535.78	$1,885,916.28	$271,348.92

Table 12 reveals that joint ordering has a significant advantage in all groups of Category I medications. Grouping orders results in about a $1.5-2 million savings compared to ordering each item individually. This model estimates that there would be a savings of approximately $62,000 annually if NMCSD should use a continuous review system over a continuing with the periodic review.

2. Sample Problems

Using a small sample of three medications the sample problems will illustrate how the costs in Table 12 were derived. Table 13 shows the summarized collected data of three medications that were used to complete this analysis. Refer back to the EOQ and Q_i formulas provided in Chapter 3 to calculate these quantities. Tables 14 and 15 show a

step-by-step example of how to calculate total cost using the given data in Tables 10 and 13. The calculation of S^* and n^* is shown in the equations directly following Table 15. The results of this small sample is joint ordering is $2,813 less expensive than ordering individually with the EOQ model.

Table 13. NMCSD Sample Data Adapted from Chopra & Meindl, 2013

Drug Name	Unit Cost	Average daily demand (Units)	Annual Demand (Units)	SD
FLUCONAZOLE (DIFLUCAN) 200MG TAB	$15.68	36	13,198	70.29
FLUOXETINE (PROZAC) PO 10MG CAP	$6.05	91	33,218	110.81
SITAGLIPTIN (JANUVIA) 25MG ORAL TAB	$12.99	42	15,280	75.77

Table 14. Economic Order Quantity Example, Periodic Review Adapted from Chopra & Meindl, 2013.

Drug Name	EOQ	Average Inventory	Cycle Stock Holding Cost	Orders per year	Annual Order Cost
FLUCONAZOLE (DIFLUCAN) 200MG TAB	1,692	1692/2=846	846*$15.68*20%= $2,653	13,198/1,692 =7.8	$340*7.8= $2,652
FLUOXETINE (PROZAC) PO 10MG CAP	4,321	4321/2=2161	2,161*$6.05*20%=$2,614	33,218/4,321 =7.7	$340*7.7= $2,618
SITAGLIPTIN (JANUVIA) 25MG ORAL TAB	2,001	2001/2=1000	1,000*$12.99 *20%=$2,598	15,280/2,000 =7.6	$340*7.6= $2,584
Subtotal			$7,865		$7,854
Total Cost					$15,719

Table 15. Joint Order Quantity Example, Periodic Review Adapted from Chopra & Meindl, 2013.

Drug Name	Di*Ci*h	Q_i	e Stock Holding	Order Cost
FLUCONAZOLE (DIFLUCAN) 200MG TAB	13,198*$15.68 *20%=41,388	13,198/9.4 =1,404	1,404/2*$15.68 *20%=$2,201	
FLUOXETINE (PROZAC) PO 10MG CAP	33,218*$6.05* 20%=40,193	33,218/9.4 =3,533	3,533/2*$6.05* 20%=$2,137	
SITAGLIPTIN (JANUVIA) 25MG ORAL TAB	15,280*$12.99 *20%=39,697	15,280/9.4 =1,625	1,635/2*$12.99 *20%=$2,147	
SubTotal	121,278		$6,485	9.4*683.11=$6,421
Total				$12,906

$$S^* = \$679 + 1.37 + 1.37 + 1.37 \quad n^* = \sqrt{\frac{41{,}388 + 40{,}193 + 39{,}697}{2 * 683.11}} = 9.4$$

3. When to reorder

Due to the relatively short lead-time to resupply inventory, the need for safety stock is greatly diminished. However, the high variability in demand negates the short lead-time advantage and necessitates at least some safety stock. The amount of safety stock at NMCSD or any pharmacy is up to the senior management and must balance the holding cost with the cost of stock outs. For this study, the service level of the items is determined by the VEN categorization of medications. Vital medications have a service level of 95 percent, essential medications have a service level of 90 percent and the non-essential medications have a service level of 85 percent. Once the *ROP* is determined a policy must be considered to decide when to reorder.

One consideration is that once any item in the reorder group is below the *ROP*, the entire group is reordered using the Q_i quantity for each item. The benefit of this policy is that it minimizes the risk of stock-outs because the whole group of medications is reordered when only one item is below the *ROP*. The potential disadvantage of this policy is that this could potentially create a temporary over-stock situation increasing the holding cost. In the long run, over a year, all of the ordered inventory should be used. Another possibility is to re-order once a certain percentage of medications in the group are below the order point. This policy would significantly increase the risk of a stock out.

V. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

Inventory management is not a one size fits all decision that can be made. Sometimes even the optimal solution may not be the right one if the constraints are present. The best way to analyze an inventory management policy is to start by deciding what to analyze. Using an ABC analysis can help differentiate the items that really need to be focused on to save money and time from those that really do not impact much. Used alone, the ABC analysis is good for some industries, but in the medical community, the most important medications are not always the ones with the highest demand or cost the most money. Patient safety concerns or accreditation requirements are just two reasons why it may be important to upgrade a medication categorized as a B or C into a more closely observed status. This shows that the VEN classification system when used in combination with the ABC analysis may provide a better picture on the inventory items that should be focused on.

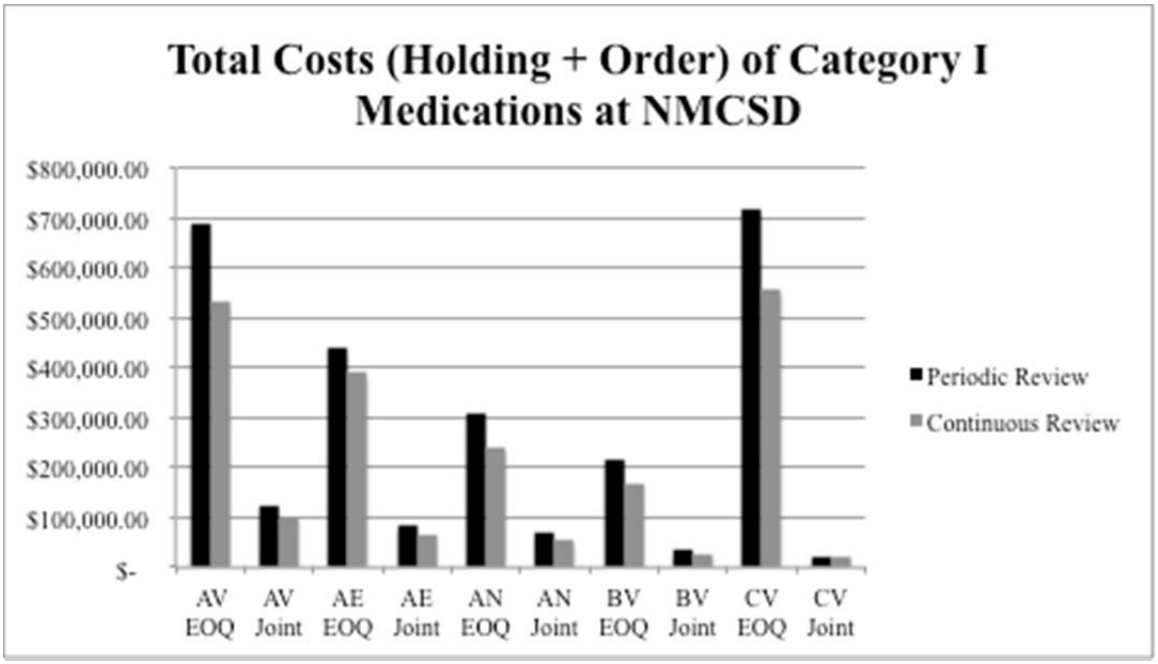
Once the items to focus on has been decided the analysis of how much and when to order and when can be done. This is accomplished first by deciding which system will be used: periodic, continuous, or a hybrid system. Using the *EOQ* formula or joint order formula the optimal re-order quantities can be calculated for a decision. The easy part is then deciding when to re-order, but this is highly dependent on the service level that is decided upon and may be different for different managers.

B. CONCLUSION

This study has differentiated NMCSD's medications into three categories using a hybrid of the ABC Analysis and VEN categorization, used personnel salaries to determine ordering costs and separated these into common and item specific costs and compared an *EOQ* with a joint ordering model. No matter which inventory system that is decided upon, the decision should be made based on it would impact the Category I medications. While the Category II and III medications would be impacted slightly, the largest benefit would come from Category I. This study determined that the joint ordering

method was 84 percent less expensive than single item *EOQ* ordering and continuous review was 18 and 19 percent less expensive than periodic review when compared to joint ordering and the *EOQ* model respectively. Figure 3 shows these cost savings graphically.

Figure 3. Total Costs (Holding + Order) of Category I Medications at NMCSD. Adapted from Chopra & Meindl, (2013).



Due to the assumptions made to create the *EOQ* model, it is overestimating the order costs and the difference between joint ordering and the *EOQ* model are likely closer in cost than the analysis shows. Another weakness when considering the *EOQ* model is that many of the items are so inexpensive that the order quantity becomes almost a full year's demand worth, making it not a realistic number. In this model a continuous review system is less expensive because it decreases the order cost by about $270 each order placed. This is the monetary cost of order building, it does not include the subjective costs of reallocating the supply personnel during those times to help with patient care and thus increasing patient safety and reducing wait times.

This study arranged the order groups based on their ABC-VEN classification, however this is not the only way to do this. An alternative would be to arrange the groups based on their coefficient of variation (CV) or simply by their demand. The results that this study determined can be seen in Tables 16 through 20.

Table 16. Continuous Review AV Medication Results. Adapted from Chopra & Meindl, (2013), Krajewski & Ritzman, (1996).

	n*	75.4			Service Level	95%	
Medication Name	JOQ	Safety Stock	Reorder Point	Medication Name	JOQ	Safety Stock	ROP
TRUVADA 200MG/300MG ORAL TAB	948	327	566	DERMA-SMOOTHE/FS OIL-FLUOCINOLONE 0.01%-	1,435	599	961
FLUTICASONE (FLONASE) 50MCG NAS INH 16GM	514	248	378	ZOLPIDEM TARTRATE (AMBIEN) 5 MG ORAL TAB	633	196	356
LANTUS SOLOSTAR 300U/3ML PREFILLED PEN	600	238	389	MOXIFLOXACIN HCL (VIGAMOX) 0.5 % OPHTHAL	123	177	207
RIZATRIPTAN (MAXALT) 10MG ORAL TABLET	50	38	51	EPINEPHRINE(EPIPEN 2-PAK)0.3MG/0.3ML IM-	14	5	8
AMLODIPINE BESYLATE (NORVASC)10MG TAB	1,148	323	612	CIPRODEX 0.3%-0.1% OTIC DROPS SUSP	194	79	128
TRIUMEQ 600/50/300 MG TABLET	501	203	330	METHYLPHENIDATE (CONCERTA)18MG TAB ER 24	457	217	332
PRECISION XTRA BLOOD GLUCOSE TEST STRIPS	7,227	1,944	3,767	VENLAFAXINE XR (EFFEXOR XR) 150MG CPSR	473	199	318
ISOTRETINOIN (ACCUTANE) 40MG CAP	726	240	423	LORATADINE (CLARITIN) 10MG TAB--PO 10MG	2,623	616	1,278
SERTRALINE (ZOLOFT) 100MG ORAL TABLET--P	1,590	468	868	CLINDAMYCIN (CLEOCIN) 150MG CAP--PO 150M	1,815	624	1,082
ONDANSETRON HCL (ZOFRAN) 4 MG ORAL TAB	624	149	306	METFORMIN HCL 500 MG ORAL TABLET	3,253	1,048	1,868
HYDROCODONE/ACETAMINOPHEN 5MG-325MG TAB	5,176	763	2,068	METHYLPHENIDATE 54MG TAB ER 24--PO 54MG	342	166	252
ORTHO-CYCLEN (0.25-0.035) 28 COUNT TAB	569	342	486	MELOXICAM (MOBIC) 7.5MG ORAL TABLET	792	300	499
ADALIMUMAB(HUMIRA)40MG/0.8ML SQ PEN	42	16	27	MINOCYCLINE HCL 100 MG ORAL CAPSULE--PO	596	249	399
HARVONI 90/400MG ORAL TAB	25	22	28	POLYETHYLENE GLYCOL 3350(SMOOTHLAX)17G/D	37,804	7,332	16,864
COMPLERA 200-25-300MG TABLET	254	145	209	SODIUM FLUORIDE1.1%(PREVIDENT 5000 PLUS)	320	298	379
FLUOXETINE (PROZAC) PO 20MG CAP--PO 20MG	1,367	478	822	SERTRALINE (ZOLOFT) 25MG ORAL TABLET--PO	465	195	312
OXYCODONE/ACETAMIN(PERCOCET) 5/325MG TAB	7,539	1,262	3,163	GABAPENTIN (NEURONTIN) 100MG CAP--PO 100	1,061	428	695
ONDANSETRON HCL (ZOFRAN) 8 MG ORAL TAB	337	130	215	PIMECROLIMUS (ELIDEL) 1% CREAM--TOP 1% C	537	247	382
FLUTICASONE (FLOVENT HFA) 110 MCG INH	369	146	239	OXYCODONE HCL(OXYCONTIN) 10 MG ER TAB	705	180	357
CLINDAMYCIN (CLEOCIN) TOP 1% GEL	199	112	163	LOSARTAN POTASSIUM (COZAAR) 50MG TABLET	731	269	453
ATRIPLA (EFAV/EMTRIC/TENOF 600-200-300)	162	107	148	ESOMEPRAZOLE (NEXIUM) 20MG PO CAP--PO 20	1,846	533	999
ISOTRETINOIN (ACCUTANE) 10MG CAPSULE	440	172	283	CITALOPRAM(CELEXA) 20MG TAB--PO 20MG TAB	515	207	337
RANITIDINE HCL (ZANTAC) 150MG TAB	5,310	1,029	2,368	CYCLOBENZAPRINE (FLEXERIL) 10MG TAB	1,533	382	769
LIDODERM 5% PATCH (LIDOCAINE)	1,501	343	721	TRETINOIN (RETIN-A MICRO) 0.04% GEL	401	150	251
TAMSULOSIN (FLOMAX EQ) 0.4MG PO CAP	1,746	453	894	BACLOFEN (LIORESAL) 10MG TAB--PO 10MG TA	647	355	518
STRIBILD 150/150/200/300MG TABLET	138	96	131	HYDROXYZINE HCL (ATARAX) 25MG ORAL TAB	1,748	530	971
VENLAFAXINE XR (EFFEXOR XR) 75MG CAP	473	199	318	ACYCLOVIR 400 MG ORAL TABLET--PO 400MG T	831	358	567
AZITHROMYCIN (ZITHROMAX) Z-PAK 5 DAY REG	95	28	52	SILDENAFIL (VIAGRA) 100MG ORAL TABLET	417	115	220
CIPROFLOXACIN (CIPRO) 500MG TAB--PO 500M	1,038	152	414	PREDNISOLONE (PRED FORTE)-OPT 1% SUSP	135	42	76
DOLUTEGRAVIR(TIVICAY) 50MG PO TAB	192	129	178	LISINOPRIL 10MG ORAL TABLET	1,536	440	828
FREESTYLE LITE TEST STRIPS	3,140	1,082	1,874	ESTRADIOL(VIVELLE-DOT)0.1MG/24HR TDRM--T	227	79	137
OXYCODONE (OXYCONTIN) 20MG SR TAB	370	195	288	OXYCODONE HCL/ACETAMINOPHEN 5-325MG TAB	944	309	547
GABAPENTIN (NEURONTIN) 300MG CAP--PO 300	3,595	1,017	1,923	ACYCLOVIR 800 MG ORAL TABLET--PO 800MG T	409	177	281
METFORMIN HCL 1000 MG ORAL TABLET--PO 1,	2,931	881	1,620	TESTOSTERONE(FORTESTA)10MG PER ACTUATION	20	11	16
VALACYCLOVIR (VALTREX) 1000 MG ORAL TAB	355	121	211	TACROLIMUS (PROGRAF) 1MG CAP	551	378	517
LEVOFLOXACIN 750MG ORAL TABLET	116	44	73	MIRTAZAPINE (REMERON) 15 MG ORAL TABLET	386	172	269
DULOXETINE HCL (CYMBALTA) 60 MG PO CAP	752	276	466	CETIRIZINE (ZYRTEC) 10MG TAB--PO 10MG TA	4,799	1,043	2,253
MYCOPHENOLATE MOFETIL(CELLCEPT)500MG TAB	513	328	457	SITAGLIPTIN (JANUVIA) 100MG ORAL TAB	614	237	392
AZITHROMYCIN (ZITHROMAX) 250MG TAB--PO 2	120	50	81	BUPROPION SR 150MG (WELLBUTRIN SR) TAB--	557	250	391
APIXABAN(ELIQUIS)5MG ORAL TAB--PO 5MG TA	1,586	492	892	MUPIROCIN (BACTROBAN) 2 % TOPICAL OINT.	506	116	244
RIVAROXABAN (XARELTO) 20 MG ORAL TABLET	741	262	449	SIMVASTATIN (ZOCOR) 10MG TAB--PO 10MG TA	489	183	307
METHYLPHENIDATE 36MG TAB ER 24--PO 36MG	607	247	400	LEVETIRACETAM (KEPPRA) 500MG ORAL TAB	743	351	538
AMLODIPINE BESYLATE (NORVASC)5MG TAB--PO	1,470	437	808	FENTANYL (DURAGESIC) TDRM* 100MCG/HR TDS	22	20	26
SIMVASTATIN (ZOCOR) 40MG ORAL TABLET	792	277	477	TIZANIDINE (ZANAFLEX) 4MG TAB	799	311	513
DOXYLAMINE/PYRIDOXINE(DICLEGIS)10/10MG--	925	290	523	COLCHICINE 0.6MG TABLET	692	257	431
LEVOFLOXACIN 500MG ORAL TAB	79	35	55	BUPROPION XL (WELLBUTRIN XL) 300MG TAB--	651	249	413
METRONIDAZOLE 500 MG ORAL TABLET	550	117	255	BENZONATATE (TESSALON) 100MG CAP--PO 100	1,280	372	695
ETONOGESTREL/ETHINYL ESTRADIOL(NUVARING)	48	18	30	DOCUSATE CALCIUM (SURFAK) 240MG PO CAP	12,418	2,512	5,644
TRAMADOL (ULTRAM) 50MG ORAL TABLET--PO 5	3,597	819	1,726	OXYCODONE (ROXICODONE) 1MG/ML PO SOLN	889	438	662
ESOMEPRAZOLE (NEXIUM) 40MG PO CAP--PO 40	3,030	751	1,515	DEXTROAMPHETAMINE/AMPHETAM 20MG XR CAP--	870	311	530
PREGABALIN (LYRICA) 75MG CAP--PO 75MG CA	977	380	626	METOPROLOL SUCCINATE 100MG (TOPROL XL)--	576	212	357

Table 17. Continuous Review, AE Medication Results. Adapted from Chopra & Meindl, (2013), Krajewski & Ritzman, (1996).

		n*	64.6			Service Level	90%	
Medication Name	JOQ	Safety Stock	Reorder Point		Medication Name	JOQ	Safety Stock	ROP
ATOMOXETINE (STRATTERA) 40MG CAP	210	88	125		FOLLISTIM AQ 600 U/0.72ML CARTRIDGE SQ--	13	3	5
CLINDAMYCIN (CLEOCIN-T) 1% TOP SOLN	281	126	176		ENOXAPARIN (LOVENOX) 80MG/.8ML SQ UI/SYR	89	32	48
CEPHALEXIN 250MG/5ML SUSP 200ML--PO 250M	1,064	330	518		TADALAFIL 20MG (CIALIS) TAB--PO 20MG TAB	128	30	53
PEGFILGRASTIM (NEULASTA) 6MG/0.6ML SYR	9	2	3		GOSERELIN ACET (ZOLADEX) 10.8MG DEPOT	7	2	3
THYROTROPIN ALFA(THYROGEN)1.1MG IM INJ	4	2	2		IPRATROPIUM INHALER *HFA* 12.9GM--INH 17	45	21	29
VANICREAM TOPICAL CREAM *OTC*--TOP CREA	1,413	683	932		DULOXETINE HCL (CYMBALTA) 20 MG PO CAP--	544	158	254
ONABOTULINUMTOXINA(BOTOX)200UNIT IN VIAL	23	7	11		FLUTICASONE/SALMETEROL 230-21MCG HFA INH	69	28	41
MESALAMINE (LIALDA) 1.2GM ORAL TABLET DR	1,807	443	762		DESONIDE (DESOWEN) 0.05 % TOPICAL CREAM-	262	114	161
MOMETASONE FUROATE (NASONEX) 50MCG NASAL	127	49	71		FILGRASTIM (G-CSF) 300MCG/0.5ML SYRN	12	6	9
GABAPENTIN (NEURONTIN) 600MG TAB	1,144	317	519		PREGABALIN (LYRICA) 150MG CAP--PO 150MG	891	235	392
ONABOTULINUMTOXINA(BOTOX)100UNIT IN VIAL	21	6	10		AZATHIOPRINE (IMURAN) 50MG ORAL TAB--PO	717	239	365
DIATRIZ MEGLU/DIATRI NA(GASTROGRAFIN)	7	11	13		SUMATRIPTAN (IMITREX) 6MG/.5ML SQ CARTG	19	10	14
TEMOZOLOMIDE (TEMODAR) 100MG CAP	27	13	17		KETOCONAZOLE (NIZORAL) TOP 2% CREAM	530	120	214
CLOBETASOL (OLUX) 0.05% FOAM 100GM	883	252	408		LAMOTRIGINE (LAMICTAL) 25MG ORAL TAB	555	163	261
FLUTICASONE(FLOVENT HFA) 220 MCG INH	150	45	71		LANSOPRAZOLE(PREVACID)15MG SOLUTAB	392	143	212
FILGRASTIM (G-CSF) 480MCG/0.8ML SYRN	12	6	8		ORTHO TRI-CYCLEN LO 28 DAY ORAL TABLETS	840	243	391
RALTEGRAVIR POTAS(ISENTRESS)400MG TAB	413	136	209		CALCIP/BETA(TACLONEX)0.005-0.064TOP SUSP	278	118	167
ENTECAVIR (BARACLUDE) 0.5MG ORAL TAB	167	75	104		MIRABEGRON(MYRBETRIQ) 25MG ER 24HR TAB	656	182	297
VANCOMYCIN (VANCOCIN) 125MG ORAL CAP	147	47	73		VENLAFAXINE XR (EFFEXOR XR) 37.5MG CAP	466	131	213
TENOFOVIR DISOPROXIL (VIREAD) 300 MG TAB	249	83	127		EPINEPHRINE(EPIPEN JR 2-PAK)0.15MG/0.3ML	11	3	5
CLOBETASOL (TEMOVATE)--TOP 0.05% OINT	555	395	493		MONTELUKAST SODIUM (SINGULAIR) 5MG TBCH-	387	114	182
ARIPIPRAZOLE (ABILIFY) 5MG TAB--PO 5MG T	341	95	156		CEFIXIME (SUPRAX) 100MG/5ML PO SUSP	434	152	229
FOLLISTIM AQ 900/1.08ML CARTRIDGE SQ--SQ	8	2	4		SUMATRIPTAN (IMITREX) 100MG TAB--PO 100M	86	26	41
LAMOTRIGINE (LAMICTAL) 100MG ORAL TAB	859	249	400		DABIGATRAN(PRADAXA) 150MG ORAL CAP	412	156	228
IMIQUIMOD (ALDARA)--TOP 5% CREA	127	34	57		LIDOCAINE (XYLOCAINE)--TOP 5% OINT	348	105	167
FLUCONAZOLE (DIFLUCAN) 200MG TAB--PO 200	205	90	126		NALTREXONE MICROSPHERES (VIVITROL)380MG	2	1	1
FLUOXETINE (PROZAC) PO 10MG CAP--PO 10MG	515	142	233		DONEPEZIL HCL (ARICEPT) 10 MG ORAL TAB--	203	76	112
SITAGLIPTIN (JANUVIA) 25MG ORAL TABLET	237	97	139		ENOXAPARIN (LOVENOX) 40MG/0.4ML SQ SYR--	170	45	75
SYRINGE 23GX1IN 3ML WITH NEEDLE	67	37	49		MESALAMINE(CANASA) 1000MG RECTAL SUPP	131	63	86
TACLONEX(CALCIPO/BETAMET).005/.064% OINT	437	168	245		SEVELAMER (RENVELA) 800MG PO TAB	1,452	533	790
CAPECITABINE (XELODA) 500MG TAB--PO 500M	389	121	189		RABEPRAZOLE (ACIPHEX) 20MG ORAL TAB	213	93	131
CLOBAZAM (ONFI) 2.5MG/ML ORAL SUSPENSION	1,255	544	765		PREGABALIN (LYRICA) 100MG CAP--PO 100MG	587	207	311
TOPIRAMATE (TOPAMAX) 100MG TAB	510	151	241		AMLODIPINE BESYLATE (NORVASC)2.5MG TAB--	694	168	290
CABERGOLINE (DOSTINEX) 0.5MG TABLET	97	40	57		ONABOTULINUMTOXINA (BOTOX COSMETIC) 50U	4	2	2
RIFAXIMIN (XIFAXAN) 550 MG ORAL TABLET	311	123	178		RISPERIDONE (RISPERDAL) 1MG ORAL TAB	305	172	226
ADAPALENE 0.1 % TOPICAL CREAM	96	43	60		VARDENAFIL 20MG TAB (LEVITRA)	84	25	40
ARIPIPRAZOLE (ABILIFY) 2MG ORAL TAB	257	76	121		BUMETANIDE (BUMEX) 1MG TAB	1,207	333	546
SUMATRIPTAN (IMITREX) 50MG TAB--PO 50MG	155	42	69		SITAGLIP/METFORM(JANUMET) 50-1000MG TAB	1,402	330	577
TADALAFIL (CIALIS) 5MG TAB	805	196	338		CLINDAMYCIN/BENZOYL (DUAC)1.2(1)%-5% TOP	319	84	141
MENOTROPINS (MENOPUR) 75 UNIT SUB-Q VIAL	72	20	32		TIOTROPIUM (SPIRIVA) 18MCG/CAP INH PWDR-	561	132	231
FLUTICASONE/SALMETEROL 115-21MCG HFA INH	101	39	57		CYCLOSPORINE (RESTASIS) 0.05% OPTH SOLN-	640	192	306

Table 18. Continuous Review, AN Medication Results. Adapted from Chopra & Meindl, (2013), Krajewski & Ritzman, (1996).

		n*	75.4			Service Level	95%	
Medication Name	JOQ	Safety Stock	Reorder Point		Medication Name	JOQ	Safety Stock	ROP
TRUVADA 200MG/300MG ORAL TAB	948	327	566		DERMA-SMOOTHE/FS OIL-FLUOCINOLONE 0.01%-	1,435	599	961
FLUTICASONE (FLONASE) 50MCG NAS INH 16GM	514	248	378		ZOLPIDEM TARTRATE (AMBIEN) 5 MG ORAL TAB	633	196	356
LANTUS SOLOSTAR 300U/3ML PREFILLED PEN	600	238	389		MOXIFLOXACIN HCL (VIGAMOX) 0.5 % OPHTHAL	123	177	207
RIZATRIPTAN (MAXALT) 10MG ORAL TABLET	50	38	51		EPINEPHRINE(EPIPEN 2-PAK)0.3MG/0.3ML IM-	14	5	8
AMLODIPINE BESYLATE (NORVASC)10MG TAB	1,148	323	612		CIPRODEX 0.3%-0.1% OTIC DROPS SUSP	194	79	128
TRIUMEQ 600/50/300 MG TABLET	501	203	330		METHYLPHENIDATE (CONCERTA)18MG TAB ER 24	457	217	332
PRECISION XTRA BLOOD GLUCOSE TEST STRIPS	7,227	1,944	3,767		VENLAFAXINE XR (EFFEXOR XR) 150MG CPSR	473	199	318
ISOTRETINOIN (ACCUTANE) 40MG CAP	726	240	423		LORATADINE (CLARITIN) 10MG TAB--PO 10MG	2,623	616	1,278
SERTRALINE (ZOLOFT) 100MG ORAL TABLET--P	1,590	468	868		CLINDAMYCIN (CLEOCIN) 150MG CAP--PO 150M	1,815	624	1,082
ONDANSETRON HCL (ZOFRAN) 4 MG ORAL TAB	624	149	306		METFORMIN HCL 500 MG ORAL TABLET	3,253	1,048	1,868
HYDROCODONE/ACETAMINOPHEN 5MG-325MG TAB	5,176	763	2,068		METHYLPHENIDATE 54MG TAB ER 24--PO 54MG	342	166	252
ORTHO-CYCLEN (0.25-0.035) 28 COUNT TAB	569	342	486		MELOXICAM (MOBIC) 7.5MG ORAL TABLET	792	300	499
ADALIMUMAB(HUMIRA)40MG/0.8ML SQ PEN	42	16	27		MINOCYCLINE HCL 100 MG ORAL CAPSULE--PO	596	249	399
HARVONI 90/400MG ORAL TAB	25	22	28		POLYETHYLENE GLYCOL 3350(SMOOTHLAX)17G/D	37,804	7,332	16,864
COMPLERA 200-25-300MG TABLET	254	145	209		SODIUM FLUORIDE1.1%(PREVIDENT 5000 PLUS)	320	298	379
FLUOXETINE (PROZAC) PO 20MG CAP--PO 20MG	1,367	478	822		SERTRALINE (ZOLOFT) 25MG ORAL TABLET--PO	465	195	312
OXYCODONE/ACETAMIN(PERCOCET) 5/325MG TAB	7,539	1,262	3,163		GABAPENTIN (NEURONTIN) 100MG CAP--PO 100	1,061	428	695
ONDANSETRON HCL (ZOFRAN) 8 MG ORAL TAB	337	130	215		PIMECROLIMUS (ELIDEL) 1% CREAM--TOP 1% C	537	247	382
FLUTICASONE (FLOVENT HFA) 110 MCG INH	369	146	239		OXYCODONE HCL(OXYCONTIN) 10 MG ER TAB	705	180	357
CLINDAMYCIN (CLEOCIN) TOP 1% GEL	199	112	163		LOSARTAN POTASSIUM (COZAAR) 50MG TABLET	731	269	453
ATRIPLA (EFAV/EMTRIC/TENOF 600-200-300)	162	107	148		ESOMEPRAZOLE (NEXIUM) 20MG PO CAP--PO 20	1,846	533	999
ISOTRETINOIN (ACCUTANE) 10MG CAPSULE	440	172	283		CITALOPRAM(CELEXA) 20MG TAB--PO 20MG TAB	515	207	337
RANITIDINE HCL (ZANTAC) 150MG TAB	5,310	1,029	2,368		CYCLOBENZAPRINE (FLEXERIL) 10MG TAB	1,533	382	769
LIDODERM 5% PATCH (LIDOCAINE)	1,501	343	721		TRETINOIN (RETIN-A MICRO) 0.04% GEL	401	150	251
TAMSULOSIN (FLOMAX EQ) 0.4MG PO CAP	1,746	453	894		BACLOFEN (LIORESAL) 10MG TAB--PO 10MG TA	647	355	518
STRIBILD 150/150/200/300MG TABLET	138	96	131		HYDROXYZINE HCL (ATARAX) 25MG ORAL TAB	1,748	530	971
VENLAFAXINE XR (EFFEXOR XR) 75MG CAP	473	199	318		ACYCLOVIR 400 MG ORAL TABLET--PO 400MG T	831	358	567
AZITHROMYCIN (ZITHROMAX) Z-PAK 5 DAY REG	95	28	52		SILDENAFIL (VIAGRA) 100MG ORAL TABLET	417	115	220
CIPROFLOXACIN (CIPRO) 500MG TAB--PO 500M	1,038	152	414		PREDNISOLONE (PRED FORTE)-OPT 1% SUSP	135	42	76
DOLUTEGRAVIR(TIVICAY) 50MG PO TAB	192	129	178		LISINOPRIL 10MG ORAL TABLET	1,536	440	828
FREESTYLE LITE TEST STRIPS	3,140	1,082	1,874		ESTRADIOL(VIVELLE-DOT)0.1MG/24HR TDRM--T	227	79	137
OXYCODONE (OXYCONTIN) 20MG SR TAB	370	195	288		OXYCODONE HCL/ACETAMINOPHEN 5-325MG TAB	944	309	547
GABAPENTIN (NEURONTIN) 300MG CAP--PO 300	3,595	1,017	1,923		ACYCLOVIR 800 MG ORAL TABLET--PO 800MG T	409	177	281
METFORMIN HCL 1000 MG ORAL TABLET--PO 1,	2,931	881	1,620		TESTOSTERONE(FORTESTA)10MG PER ACTUATION	20	11	16
VALACYCLOVIR (VALTREX) 1000 MG ORAL TAB	355	121	211		TACROLIMUS (PROGRAF) 1MG CAP	551	378	517
LEVOFLOXACIN 750MG ORAL TABLET	116	44	73		MIRTAZAPINE (REMERON) 15 MG ORAL TABLET	386	172	269
DULOXETINE HCL (CYMBALTA) 60 MG PO CAP	752	276	466		CETIRIZINE (ZYRTEC) 10MG TAB--PO 10MG TA	4,799	1,043	2,253
MYCOPHENOLATE MOFETIL(CELLCEPT)500MG TAB	513	328	457		SITAGLIPTIN (JANUVIA) 100MG ORAL TAB	614	237	392
AZITHROMYCIN (ZITHROMAX) 250MG TAB--PO 2	120	50	81		BUPROPION SR 150MG (WELLBUTRIN SR) TAB--	557	250	391
APIXABAN(ELIQUIS)5MG ORAL TAB--PO 5MG TA	1,586	492	892		MUPIROCIN (BACTROBAN) 2 % TOPICAL OINT.	506	116	244
RIVAROXABAN (XARELTO) 20 MG ORAL TABLET	741	262	449		SIMVASTATIN (ZOCOR) 10MG TAB--PO 10MG TA	489	183	307
METHYLPHENIDATE 36MG TAB ER 24--PO 36MG	607	247	400		LEVETIRACETAM (KEPPRA) 500MG ORAL TAB	743	351	538
AMLODIPINE BESYLATE (NORVASC)5MG TAB--PO	1,470	437	808		FENTANYL (DURAGESIC) TDRM* 100MCG/HR TDS	22	20	26
SIMVASTATIN (ZOCOR) 40MG ORAL TABLET	792	277	477		TIZANIDINE (ZANAFLEX) 4MG TAB	799	311	513
DOXYLAMINE/PYRIDOXINE(DICLEGIS)10/10MG--	925	290	523		COLCHICINE 0.6MG TABLET	692	257	431
LEVOFLOXACIN 500MG ORAL TAB	79	35	55		BUPROPION XL (WELLBUTRIN XL) 300MG TAB--	651	249	413
METRONIDAZOLE 500 MG ORAL TABLET	550	117	255		BENZONATATE (TESSALON) 100MG CAP--PO 100	1,280	372	695
ETONOGESTREL/ETHINYL ESTRADIOL(NUVARING)	48	18	30		DOCUSATE CALCIUM (SURFAK) 240MG PO CAP	12,418	2,512	5,644
TRAMADOL (ULTRAM) 50MG ORAL TABLET--PO 5	3,597	819	1,726		OXYCODONE (ROXICODONE) 1MG/ML PO SOLN	889	438	662
ESOMEPRAZOLE (NEXIUM) 40MG PO CAP--PO 40	3,030	751	1,515		DEXTROAMPHETAMINE/AMPHETAM 20MG XR CAP--	870	311	530
PREGABALIN (LYRICA) 75MG CAP--PO 75MG CA	977	380	626		METOPROLOL SUCCINATE 100MG (TOPROL XL)--	576	212	357

Table 19. Continuous Review, BV Medication Results. Adapted from Chopra & Meindl, (2013), Krajewski & Ritzman, (1996).

		n*	26.8			Service Level	95%	
Medication Name	JOQ	Safety Stock	Reorder Point		Medication Name	JOQ	Safety Stock	ROP
NORELGESTROMIN/ETHIN.ESTRADIOL PATCH--TD	188	22	36		ALPRAZOLAM 0.5 MG ORAL TABLET	1947	284	427
ALBUTEROL SULFA(PROAIR HFA)90MCG INH HFA	432	30	61		WARFARIN SODIUM 5MG TABLET (GENERIC)	6183	635	1087
AUGMENTIN XR AMOX/POT 1000-62.5MG TAB--P	984	107	179		PSEUDOEPHEDRINE (SUDAFED) 30MG TAB *OTC*	3784	260	537
HYDROCODONE/ACETAMINOPHEN 10MG-325MG TA	3754	338	612		IBUPROFEN(ADVIL)100MG/5ML PO SUSP OTC--P	34797	1664	4211
MOXIFLOXACIN HCL (AVELOX) 400MG ORAL TAB	423	47	78		AMOXICILLIN/K CLAVULANATE 500-125MG TAB-	430	47	78
BUSPIRONE (BUSPAR) PO 10MG TAB--PO 10MG	2787	400	604		FENTANYL (DURAGESIC) TDRM 25MCG/HR TDSY-	96	28	35
INSULIN ASPART (NOVOLOG FLEXPEN) 100/ML-	1745	568	696		GUAIFENESIN LA (MUCINEX) PO 600MG TBSR--	2319	199	369
AZITHROMYCIN (TRI-PAK) 500MG TAB	159	25	36		NITROFURANTOIN MONO-MACRO(MACROBID)100	2497	165	348
TRAZODONE (DESYREL TYPE) 50MG TABLET--PO	4404	396	719		OLOPATADINE HCL(PATADAY) 0.2% OPHTH DROP	109	12	20
METHYLPHENIDATE 27MG TAB ER 24--PO 27MG	1680	219	342		PROCTOFOAM-HC (EQUIV) RECT FOAM--RECT 1%	259	34	52
TELMISARTAN (MICARDIS) 40MG TAB--PO 40MG	2293	255	423		COTRIMOXAZOLE (SEPTRA) 40MG/5ML PO SUSP-	6078	732	1177
TELMISARTAN (MICARDIS) 80MG TAB--PO 80MG	2179	217	377		IBUPROFEN (MOTRIN) 800MG ORAL TABLET--PO	38643	1461	4290
CLOMIPHENE (CLOMID) PO 50MG TABLET--PO 5	395	48	77		CO-TRIMOXAZOLE(SEPTRA DS) 800/160MG TAB-	1218	146	235
TRAZODONE (DESYREL TYPE) 100MG TABLET--P	2038	254	403		REFRESH TEARS 0.5% OPHT DROP	3110	235	462
HYDROCODONE/CHLORPH(TUSSIONEX)10-8MG/5ML	4636	499	839		OMEPRAZOLE 20 MG ORAL CAPSULE DR--PO 20M	16648	1040	2259
METFORMIN HCL (GLUCOPHAGE XR) 500MG TAB-	3928	476	763		PHENAZOPYRIDINE HCL 100 MG ORAL TABLET	1287	71	165
EE/DROSPIRENONE (YAZ) 0.02-3 MG ORAL TAB	3572	451	712		TESTOSTERONE CYPIONATE 200MG/ML INJ 1ML	202	25	40
DEXTROAMPHETAMINE/AMPHETAM 30MG XR CAP--	2304	260	428		AMOXICILLIN 250MG/5ML ORAL SUSP	19995	1428	2892
FLUTICASONE/SALMETEROL 250-50MCG INH DSK	99	23	30		ESCITALOPRAM 10MG (LEXAPRO) TAB	2313	247	417
LISINOPRIL 5MG ORAL TABLET	2998	281	501		CLONAZEPAM (KLONOPIN) PO 0.5MG TAB--PO 0	1780	235	365
FLUCONAZOLE (DIFLUCAN) 150MG TAB--PO 150	142	17	27		FOLIC ACID (FOLATE) 1MG TAB--PO 1MG TAB	3696	371	641
MECLIZINE HCL (ANTIVERT) 25 MG ORAL TAB-	1928	178	319		CETIRIZINE (ZYRTEC) 5MG/5ML PO SOLN--PO	13314	1215	2190
METOPROLOL SUCCINATE 50MG (TOPROL XL)	3336	341	585		AZITHROMYCIN (ZITHROMAX) 1GM PACK	27	3	5
CHORIONIC GONADOTROPIN(OVIDREL)250MCG SQ	44	4	7		ALLOPURINOL 100 MG ORAL TABLET--PO 100MG	2943	332	548
LANTUS INSULIN 100U/ML INJ	857	108	171		BUPROPION XL (WELLBUTRIN XL)150MG TAB--P	2892	321	532
OXYCODONE 5MG IR TAB ORAL--PO 5MG TAB	11642	757	1609		PROMETHAZINE HCL 25MG ORAL TABLET	2496	180	363
KETOCONAZOLE--TOP 2% SHAM	7419	746	1289		CELLUVISC 1% OPT DROP *OTC*--OPT AMP	4119	311	612
ONDANSETRON (ZOFRAN ODT) 4 MG TAB RAPDIS	6318	260	723		BENZOCAINE/MENTHOL (CEPACOL SORE THROAT)	367	35	62
FENTANYL (DURAGESIC) TDRM 50MCG/HR TDSY-	79	18	24		PANTOPRAZOLE SODIUM 40 MG ORAL TABLET DR	2664	285	480
METHOTREXATE NA(METHOTREXATE)2.5MG TAB	1331	169	266		AZITHROMYCIN(ZITHROMAX)200MG/5ML PO SUSP	816	215	275
CELECOXIB (CELEBREX) PO 200MG CAP--PO 20	3160	287	518		WARFARIN SODIUM 2.5MG (GENERIC) TAB	4327	469	786
SILDENAFIL (VIAGRA) 50MG ORAL TABLET	562	61	102		MORPHINE (MS CONTIN) 30MG TBSR--PO 30MG	370	80	107
DEXTROAMPHETAMINE/AMPHETAM 10MG XR CAP--	1618	197	315		ATORVASTATIN (LIPITOR) 80MG TAB	5066	396	767
OXYCODONE (OXYCONTIN) 40MG SR TAB	434	86	118		NAPROXEN (NAPROSYN) 500 MG ORAL TABLET	18915	921	2306
INSULIN ASPART (NOVOLOG) 100U/ML SUB-Q--	991	124	197		NORETHINDRONE-E.ES-IRON 1MG-20(28) TAB	2429	313	491
FENTANYL (DURAGESIC) TDRM 75MCG/HR TDSY-	42	11	14		ALFUZOSIN HCL (UROXATRAL) 10MG ER TAB--P	2194	250	411
ATENOLOL 50 MG TAB	2442	266	445		GUAIFENESIN/CODEINE100-10MG/5ML ORAL SYR	18573	1638	2998
ASPIRIN (ASPIRIN EC) 81 MG ORAL TABLET--	42216	3111	6202		NEEDLES INSULIN(SURE COMFORT)32GX0.25 IN	7648	822	1382
NORETHINDRONE (NOR-Q-D) 0.35 MG ORAL TAB	6446	412	884		CHOLECALCIFEROL(VITAMIN D3/D)400IU/ML PO	7854	1676	2251
OMEPRAZOLE (FIRST-OMEPRAZOLE) 2 MG/ML	5520	656	1060		LUBRICANT EYE DROPS (GENTEAL) *OTC*	1663	174	296
ELECTROLYTE MIXTURE (CO-LYTE GOLYTELY)	458	490	524		CLOTRIMAZOLE (MYCELEX) 1% CRM *OTC*--TOP	1422	132	236
ACETAMINOPHEN(MAPAP)160MG/5MLORAL ELIXIR	40617	1856	4830		PROGESTERONE IN OIL 50MG/ML VIAL*NF*	758	78	133
CHLORHEXIDINE GLUCONATE 0.12 % MOUTHWASH	84234	6076	12244		LORAZEPAM (ATIVAN) PO 1MG TAB--PO 1MG TA	1100	153	234
PENICILLIN V K 500MG ORAL TABLET	878	97	161		OLOPATADINE HCL (PATANOL) 0.1 % OPH DROP	107	14	21
ATENOLOL 25 MG TAB	2083	237	389		MORPHINE (MS CONTIN) 15MG TBSR--PO 15MG	584	103	146
HYDROXYZINE HCL (ATARAX) 10MG ORAL TAB	2549	314	501		DIAZEPAM (VALIUM) 5MG PO TAB--PO 5MG TAB	4269	351	664
POLYMYXIN B TRIMETHOPRIM OPTH SOLN--OPT	514	41	79		METOPROLOL SUCCINATE 25MG (TOPROL XL)	3169	305	537
NAPROXEN (NAPROSYN) 375 MG ORAL TABLET	1547	162	276		LORATADINE/P-EPHED (CLARITIN-D) 12HR--PO	1403	161	263

Table 20. Continuous Review, CV Medication Results. Adapted from Chopra & Meindl, (2013), Krajewski & Ritzman, (1996).

		n*	26.8			Service Level	95%	
Medication Name	JOQ	Safety Stock	Reorder Point		Medication Name	JOQ	Safety Stock	ROP
NORELGESTROMIN/ETHIN.ESTRADIOL PATCH--TD	188	22	36		ALPRAZOLAM 0.5 MG ORAL TABLET	1947	284	427
ALBUTEROL SULFA(PROAIR HFA)90MCG INH HFA	432	30	61		WARFARIN SODIUM 5MG TABLET (GENERIC)	6183	635	1087
AUGMENTIN XR AMOX/POT 1000-62.5MG TAB--P	984	107	179		PSEUDOEPHEDRINE (SUDAFED) 30MG TAB *OTC*	3784	260	537
HYDROCODONE/ACETAMINOPHEN 10MG-325MG TA	3754	338	612		IBUPROFEN(ADVIL)100MG/5ML PO SUSP OTC--P	34797	1664	4211
MOXIFLOXACIN HCL (AVELOX) 400MG ORAL TAB	423	47	78		AMOXICILLIN/K CLAVULANATE 500-125MG TAB-	430	47	78
BUSPIRONE (BUSPAR) PO 10MG TAB--PO 10MG	2787	400	604		FENTANYL (DURAGESIC) TDRM 25MCG/HR TDSY-	96	28	35
INSULIN ASPART (NOVOLOG FLEXPEN) 100/ML-	1745	568	696		GUAIFENESIN LA (MUCINEX) PO 600MG TBSR--	2319	199	369
AZITHROMYCIN (TRI-PAK) 500MG TAB	159	25	36		NITROFURANTOIN MONO-MACRO(MACROBID)100	2497	165	348
TRAZODONE (DESYREL TYPE) 50MG TABLET--PO	4404	396	719		OLOPATADINE HCL(PATADAY) 0.2% OPHTH DROP	109	12	20
METHYLPHENIDATE 27MG TAB ER 24--PO 27MG	1680	219	342		PROCTOFOAM-HC (EQUIV) RECT FOAM--RECT 1%	259	34	52
TELMISARTAN (MICARDIS) 40MG TAB--PO 40MG	2293	255	423		COTRIMOXAZOLE (SEPTRA) 40MG/5ML PO SUSP-	6078	732	1177
TELMISARTAN (MICARDIS) 80MG TAB--PO 80MG	2179	217	377		IBUPROFEN (MOTRIN) 800MG ORAL TABLET--PO	38643	1461	4290
CLOMIPHENE (CLOMID) PO 50MG TABLET--PO 5	395	48	77		CO-TRIMOXAZOLE(SEPTRA DS) 800/160MG TAB-	1218	146	235
TRAZODONE (DESYREL TYPE) 100MG TABLET--P	2038	254	403		REFRESH TEARS 0.5% OPHT DROP	3110	235	462
HYDROCODONE/CHLORPH(TUSSIONEX)10-8MG/5ML	4636	499	839		OMEPRAZOLE 20 MG ORAL CAPSULE DR--PO 20M	16648	1040	2259
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NAPROXEN (NAPROSYN) 375 MG ORAL TABLET	1547	162	276		LORATADINE/P-EPHED (CLARITIN-D) 12HR--PO	1403	161	263

C. RECOMMENDATIONS

This study has solidified two big ideas in inventory management; grouping is a very good and easy way to reduce costs and a continuous review system is the most accurate and efficient inventory system. NMCSD should consider adopting a group ordering strategy that would reduce the number of orders made per year and thus reduce total cost and begin looking into costs associated with implementing a continuous review system.

D. AREAS FOR FURTHER RESEARCH

Logistical areas of research that can benefit Navy Pharmacy and inventory management are:

- Re-visit the order cost assumptions providing more in-depth analysis of the order cost and increasing their accuracy
- Cost-benefit analysis looking specifically at a continuous review system
- Investigate pooling inventory regionally, nationally or at one location to cover hospitals and clinics in a local catchment area.
- Perform experimentation to better split the S and S^* cost parameters

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